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6. AUTHORS John Fricks, Gustavo Didier	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES	8. PERFORMING ORGANIZATION REPORT NUMBER
Pennsylvania State University Office of Sponsored Programs 110 Technology Center University Park, PA 16802 -7000	

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14. ABSTRACT

The goal of this STIR grant was to initiate a research program on statistical inference and stochastic simulation to analyze time series data from passive microrheology experiments of biofluids, especially mucus. During the time of the grant, progress was made on both the theoretical analysis of such experiments and building of computational tools. Two students completed theses partially supported by this grant.

15. SUBJECT TERMS

Stochastic Simulation, Microrheology, Statistical Inference, Time Series Analysis

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			John Fricks
UU	UU	UU	UU		19b. TELEPHONE NUMBER 814-865-3235

Report Title

Final Report for Statistical Inference and Stochastic Simulation for Microrheology

ABSTRACT

The goal of this STIR grant was to initiate a research program on statistical inference and stochastic simulation to analyze time series data from passive microrheology experiments of biofluids, especially mucus. During the time of the grant, progress was made on both the theoretical analysis of such experiments and building of computational tools. Two students completed theses partially supported by this grant.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

"Detection of Heterogeneity in Microrheological Experiments."
AMS Fall Southeastern Section Meeting.
Tulane University. New Orleans, LA. October 2012.

Number of Presentations: 1.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Paper

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Jason Bernstein	0.50	
FTE Equivalent:	**0.50**	
Total Number:	**1**	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
John Fricks	0.10	
Gustavo Didier	0.10	
FTE Equivalent:	**0.20**	
Total Number:	**2**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME
Jason Bernstein
Total Number: 1

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

1 a. Tulane University

1 b. Administrators of the Tulane Educat
6823 St. Charles Avenue
New Orleans LA 701185665

Sub Contractor Numbers (c): 4770-TU-USA-0512
Patent Clause Number (d-1):
Patent Date (d-2):
Work Description (e): Assisted PI with development of statistical and simulation for subdiffusive processes in b
Sub Contract Award Date (f-1): 11/30/12 12:00AM
Sub Contract Est Completion Date(f-2): 6/6/13 12:00AM

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Inventions (DD882)

Scientific Progress

The goal of this STIR project was to initiate a research program developing statistical inference and stochastic simulation tools for problems of diffusion in biofluids. Our proposed work fit into a broad biophysical research effort on human lung biology. This research was conducted in the context of a multidisciplinary diffusion research group with members in several institutions such as Penn State University, UNC-Chapel Hill, Tulane University, etc., and whose fields of expertise comprise diverse areas such as Applied Mathematics, Probability and Statistics, and Experimental Physics. The group has been attracting funding from federal agencies such as NIH and NSF. This grant consisted of initial aspects of the applied probabilistic and statistical component of the overall work. In this context, one central aspect of our research effort was the use and develop methods within a biophysical framework, as opposed to taking a model-free, phenomenological approach. This means that our current and future results are directly relevant for the evaluation of models for microrheology, such as the GLE, and immediately interpretable in physical terms. This has been intended to not only maximize the impact of our work in the broader microrheology research community, but also to enhance interdisciplinary interaction within our diffusion group and with respect to data-driven biophysical modeling.

We focued on the following action points. For Spectral Methods, we proposed to

- Exploit traditional methods of semiparametric spectral density estimation to estimate and establish the asymptotic subdiffusivity from data for single bead paths.
- Devise spectral domain goodness-of-fit tests for relevant subclasses of biophysical models for the non-asymptotic dependency structures of paths, confirming or casting doubt on tra- ditional models such as the GLE.

For Heterogeneity, we proposed to

- Test for heterogeneity within and across paths in the subdiffusive regime by developing the asymptotics of parametric and non-parametric methods.
- Test for heterogeneity across paths int he diffusive regime by using extensions to the Kalman framework and standard spectral density estimation.
- Test for heterogeneity within paths both within and outside of the GLE framework by using spectral methods and extensions of switching methods.
- Explore and identify alternative models which incorporate heterogeneity including Markov switching-type models.

We have accomplished a significan number of our proposed aims. In particular, we have

- tested three competing detectors of subdiffusion
- have been surprised by the solid performance of the most commonly used, MSD
- have shown the superior performance of wavelet regression in more real world settings.

This work was done supporting an undergraduate and master's thesis. In addition, we have developed a computer package for the R language which implements these methods along with related simulation methods. This package is extendable, and we are working on incorporation of switching models.

In addition, we have mad significant progress on the theoretical development of the MSD estimator. This estimator was derived intuitively and is the most commonly used estimator to evaluate subdiffusion in microrheology type data. Prof. Didier was able to demonstrate the asymptotics of such an estimator, which displays a central limit type behavior in some regimes and Rosenblatt type limits in others. This result demonstrates that there are both interesting applied problems in this work, but connections to interesting mathematical results.

Technology Transfer